DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]Especially this invention relates to the manufacturing method of the electrostrictive actuator excellent in the adhesive strength of the joining interface of the internal electrode layer side of a laminated type sintered body, and the ceramics which have piezoelectric property about the manufacturing method of an electrostrictive actuator.
[0002]
[Description of the Prior Art]The manufacturing method of the conventional electrostrictive actuator is explained using drawing 2. Drawing 2 (a) is the sectional view which formed the internal electrode layers 3 and 5 by print processes, and formed the internal electrode layer 2 in both sides of the green sheet 4 which consists of ceramics which have piezoelectric property by print processes like one field of the protective layer 1 of the upper and lower sides using the paste state electrode material. The internal electrode layer has not invaded into the green sheet which consists of ceramics which have piezoelectric property.
[0003]Drawing 2 (b) is a sectional view of the laminated type sintered body produced by being stuck by pressure, unifying, applying a pressure to a laminating direction and sintering [a pyrolysis's removing the binder in the this unified layered product, and] it, applying heat to the layered product which accumulated the green sheet of drawing 2 (a) one by one, and formed the protective layer 1 in the upper and lower sides. The internal electrode layer has not invaded into ceramics in the joining interface of the internal electrode layer in a sintered compact, and ceramics.
[0004]Next, exterior electrodes are formed and an electrostrictive actuator is manufactured so that said internal electrode layer located in this laminated type sintered body side of drawing 2 (b) may be covered using an insulation material to set further, and said insulating layer may be covered and it may flow to set further to other conductive layers. A boundary with the green sheet 4 which comprises the ceramics which have not invaded into the ceramics with which the internal electrode layer of the manufactured electrostrictive actuator has piezoelectric property (6, 7). The well-known example which gave the internal electrode layer to both sides of the green sheet, and manufactured the electrostrictive actuator is hardly found, but (JP,7-169999,A) is seen uniquely.An internal electrode layer is given to this to one field or both sides, after drying, these [58] are accumulated, heat

crimping is carried out, and it is indicated briefly that the electrostrictive actuator was manufactured.
[0005]
[Problem(s) to be Solved by the Invention]Using the method of forming an internal electrode layer by print processes, we repeated the experiment, and when doing the method of forming an internal electrode layer what, we investigated in detail about whether adhesive strength is improved. It turned out in 2a side, i.e., the interface of an internal electrode layer and ceramics, of drawing 2 (b) that the adhesive strength of each joining interface of the electrostrictive actuator manufactured by the laminated layers method indicated by the gazette mentioned above is weak. This is because the wettability of an internal electrode material and ceramics is bad and it is that ceramics only touch the internal electrode layer. On the other hand, the adhesive strength of 2b interface is strong. This is because mutual wettability is extremely excellent because of contact of internal electrode layer sides, i.e., a metal surface.
[0006]The purpose of this invention gives an internal electrode layer to both sides of the green sheet which consists of ceramics which have piezoelectric property, and adhesive strength of the interface of the internal electrode layer of the electrostrictive actuator which laminated two or more [of these] and manufactured them, and ceramics is enlarged, It is in providing the manufacturing method of the electrostrictive actuator excellent in durable performance.
[0007]
[Means for Solving the Problem]To both sides of a green sheet which consists of ceramics which have piezoelectric property, a manufacturing method of an electrostrictive actuator of this invention. A green sheet which attached an internal electrode layer for a paste state conducting material by print processes is laminated, In an electrostrictive actuator produced at temperature which a binder in a green sheet mobilizes by removing a binder contained in a green sheet after sticking by pressure, and sintering, a part of internal electrode layer invades into ceramics which have piezoelectric property, and it forms complex tissue. Mechanical connection produces the method of this invasion from becoming mesh shape, and adhesive strength of this interface becomes large. Therefore, durable performance of an electrostrictive actuator which manufactured an internal electrode layer as invaded into ceramics is excellent in several steps of durable performances compared with an actuator which attached and manufactured an internal electrode layer which has not invaded into ceramics.
[0008]
[Embodiment of the Invention](Example 1) The example of the manufacturing method of the electrostrictive actuator of this invention is described using a drawing. Drawing 1 is the principal part which shows the manufacturing method of the lamination type electrostrictive actuator by the 1st example of this invention. The protective layer 1 and the green sheet 4 are ceramic green sheets which have piezoelectric property, and a part of glass component is contained for the metal the internal electrode layers 2, 3, and 5 given to one field of the protective layer 1 and both sides of a green sheet excelled [metal] in conductivity with the main ingredients. Although grant of an internal electrode layer is formed by print processes, if green sheet density is made small in this case, a part of electrode layer will invade into the gap part of a green sheet, and it will form complex tissue.
[0009]After drying the green sheet which gave the internal electrode layer, as shown in drawing 1, a

protective layer is accumulated for said green sheet on 50 sheets and the upper and lower sides, and a layered product is produced. However, the number of sheets of a piling direction is omitting the figure. The layered product was heated at 130 **, and it stuck by pressure and unified by 10MPa. Next, this layered product is heated at 850 **, passing air to a tubular furnace, and after a pyrolysis removed the binder contained in a green sheet, it was made to sinter at 1260 ** in an oxidizing atmosphere. Naturally, the complex tissue layer is formed in the joining interface 1a of boundary 8' with the ceramics which have the piezoelectric property into which a part and a part of internal electrode layer invaded, and 9' also in the laminated type sintered body. The thickness of an internal electrode is [in / including the complex tissue formative layer / a protective layer] 2 micrometers, and the thickness of a field is [while gave both sides of ceramics and] 1 micrometer.

[0010]Next, said conductive layer located in the side of the layered product sintered although the graphic display was omitted is covered using an insulation material to set further, Exterior electrodes are formed so that said insulation material may be covered and it may energize to set further to other conductive layers, and the example which carried out the reliability trial to the conventional electrostrictive actuator (that is, the internal electrode layer has not invaded into a ceramic layer) shown in the lamination type electrostrictive actuator and drawing 2 of this example is described.

[0011]A number of layers when the thickness of ceramic layer 4' of drawing 1 (b) counts 120 micrometers, internal electrode layer 2', and 3' with one layer a sample 60 layers, In the thickness of protective layer 1' of two upper and lower sides, the shape of a section respectively vertical to 2 mm and 4 mm, and a displacement direction has 5 mm x 5 mm, and the structure where the length of a displacement direction is 18 mm. Ceramic 4' which has piezoelectric property is the perovskite structure oxide which replaced a part of Pb of PZT (Pb0.64, ZrO_2 0.24, $TiO_2$0.11) by Sr, Internal electrode layer 2' and 3' are Ag65% and Pd35% of silver-PARAJUUMU mixed powder electrodes.

[0012]The insulating material of figure abbreviation is way acid system glass, and outer electrode layers used silver as the conductor. Silica system glass was used for the protective layer which covers said periphery. Ten pieces were used by having made into the test sample the electrostrictive actuator manufactured as mentioned above, and the operational test was done by the conditions shown below. As an operating condition, the outline 300 - the voltage of -1500V were impressed by the with the load 200N and a frequency of 100 Hz square wave drive, and it was considered as the amount of displacement of 18 micrometers. And the interface of an internal electrode layer and a ceramic layer exfoliated, it wound about until ceramics caused destruction and the amount of displacement of 18 micrometers was no longer obtained, and the number of times was checked, and the result was shown in drawing 3.

[0013]In the electrostrictive actuator of the comparative example, the percentage which ceramics did not destroy in operation of the $5x10^7$ time was 0%. That is, in the case of a comparative example, the amount of displacement of 18 micrometers of a layered product is no longer obtained. On the other hand, in the electrostrictive actuator of Example 1, the value with a as high rate which ceramics did not destroy even if it carried out $1x10^9$ time operation as 65% was obtained. Therefore, the electrostrictive actuator of this invention can increase a number of times operation until ceramics break, and drive durability.

[0014](Example 2) In the method of forming an internal electrode in both sides of the green sheet which consists of ceramics which have piezoelectric property, the thickness of an internal electrode includes the complex tissue formative layer, and the thickness of one field is 0.5 micrometer. The thickness of other fields is 1.5 micrometers. It manufactured like other Examples 1. A formation order of the internal electrode formed the thinner one previously, and formed the thicker one later. This electrostrictive actuator was similarly estimated as Example 1, and the result was shown in drawing 3. The electrostrictive actuator of Example 2 showed the same result as the actuator of Example 1. A boundary with the ceramics with which 6 and 7' has an internal electrode and the piezoelectric property into which it has not invaded, and 8 and 9 are the boundaries of an internal electrode layer and the ceramics which have the piezoelectric property into which the part invaded.

[0015]

[Effect of the Invention]According to this invention, a part of internal electrode layer has invaded into the green sheet which consists of ceramics which have piezoelectric property. For this reason, also in a laminated type sintered body, since a part of internal electrode layer has invaded into ceramics, the adhesive strength of the joining interface of an internal electrode layer side and a ceramic side increases from the intensity by conventional technology. With the stress which this generates at the time of the drive of an electrostrictive actuator, since exfoliation of an interface does not take place, destruction of ceramics can be prevented. Therefore, the electrostrictive actuator of this invention can increase a number of times operation and drive durable performance until ceramics break.

[Translation done.]